ARMORED FORCE MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

PROJECT NO. 3 - TOXIC GASES IN ARMORED VEHICLES

Final Report On

Sub-Project No. 3-13 - Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in the M7 Tank

Project No. 3-13

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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 3-13
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April 8, 1943

1. PROJECT: No. 3 - Toxic Gases in Armored Vehicles. Final Report on: Sub-Project No. 3-13, Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in the M7 Tank.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 21, 1942.

b. Purpose - To determine the extent of the hazard from fumes released by firing of the weapons in the M7 Tank.

2. DISCUSSION:

a. Methods and Conditions

(1) Fire Pattern.

(a) 75 mm gun: The weapon was fired at the rate of one round every 10 seconds in bursts of five--one burst being fired every five minutes.

(b) Machine guns: One belt of one hundred rounds, fired in approximately 2 minutes. The interval between belts was approximately 2 minutes; total for each gun, 300 rounds, in 9 minutes, 20 seconds.

(2) Ammunition. 75 mm; Super HE M48. Machine gun, Caliber .30 ball.

(3) Tank Operation. Tank buttoned up and motor running at normal idling speed. Auxiliary generator vent to engine compartment open. Wind quartering from rear, 10 mph. Full crew in tank. Two tests were carried out with the 75 mm gun. In the first, all ventilating fans were on intake; in the second, the fans were exhausting air from the tank.

(4) Analysis. Air samples were analyzed for carbon monoxide and ammonia by methods previously reported (Report on Projects No. 3-1, 3-5, February 15, 1943). Analysis for nitrous fumes were not carried out, earlier studies with the same ammunition having indicated the absence of any significant amounts. Results of the tests are given in the Appendix.

2. CONCLUSIONS:

a. 75 mm Gun.

(1) The average carbon monoxide concentration at the loader's position was 0.086% with the ventilating fans on intake. Some improvement was obtained with the fans exhausting, but not enough to insure satisfactory conditions.

(2) There was no accumulation of carbon monoxide in the tank air from one burst to another.

(3) Sufficient ammonia was present in the turret during firing to cause eye and nose irritation.

(4) Negligible amounts of fumes reached the bow members of the crews.

(5) Improvement of the turret ventilation in the M7 tank is needed.

b. Bow Machine Gun.

(1) The average carbon monoxide concentration at the breathing zone of the bow gunner was 0.053%.

(2) The blood of the bow gunner did not contain a serious accumulation of carbon monoxide.

(3) Gunner did not believe fumes or ammonia interfered with operation of weapon.

(4) Ventilation is adequate for operation of bow machine gun.

c. Turret Machine Gun.

(1) The average concentration of carbon monoxide at the loader's position was 0.173% and dropped only slightly below 0.1% during re-loading.

(2) The blood of each of the turret crew members showed dangerous accumulations of carbon monoxide.

(3) Concentration of ammonia and other irritating fumes in turret were sufficiently intense to make operation of the weapon extremely difficult and unreliable.

(4) The unsatisfactory performance of the turret machine gun resulted from the fact that the muzzle does not extend outside the exterior shield. Thus, gases escaping from the muzzle are trapped between the shield and turret and are drawn into the turret by the inward air flow.

(5) Correction of this situation requires changes in the gun mount.

4. RECOMMENDATIONS:

a. That the present turret ventilation be modified to provide increased exhaust ventilation and the exhaust intake to be relocated for more efficient removal of fumes from the 75 mm gun.

b. That the turret machine gun be remounted in such a manner as to prevent the entry of fumes from the gun muzzle into the turret.

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1 Incl.
Appendix I with
Tables 1, 2, & 3
Figs. 1, 2, 3, & 4

HEADQUARTERS ARMORED FORCE
Office of the Commanding General
Fort Knox, Kentucky

April 20, 1943

1. Recommendations are approved. However, due to limited number of vehicles scheduled for procurement, modifications are not warranted at this time.

2. Accordingly, it is further recommended that existing vehicles and vehicles presently scheduled for procurement, be not modified and that this report be re-considered when necessitated by future designs.

For the Commanding General:

/s/ C. M. Wells
C. M. WELLS,
Lieut. Colonel, A. G. D.,
Assistant Adjutant General

APPENDIX I

RESULTS

a. 75 mm gun.

The average concentration of carbon monoxide at the loader's breathing zone, with ventilating fans on intake was 0.086% (Table 1 and Fig. 1) and with fans on exhaust, it dropped to 0.045. In both cases, however, there was noticeable eye and nasal irritation in the commander's and loader's positions. Negligible amounts of fumes reached the bow members of the crew and there was no evidence of accumulations of fumes from one burst of fire to another.

In general, the conditions were not satisfactory and it is concluded that further improvement in the turret ventilation is required. While no tests have been made with a modified system of ventilation, it is believed that an exhaust system similar to that recommended for the M-4 medium tanks would effectively remove the fumes from the 75 mm gun.

b. Turret machine gun.

The average concentration of carbon monoxide at the loader's breathing zone was 0.173% and failed to drop below 0.1% during the period of reloading. (Fig. 3) During exposure to fumes from this gun, the blood concentration of carbon monoxide for the turret crew members increased at an alarming rate, reaching concentrations of 16, 18, and 23% in only 9 minutes (Table 3). These results indicate clearly that a major carbon monoxide hazard results from the firing of the turret machine gun. In addition to the high carbon monoxide, concentrations of ammonia and other irritating fumes were sufficiently intense to make operation of the weapon extremely difficult and unreliable.

The much higher concentrations of carbon monoxide found with this gun, in contrast to previous findings on machine guns result, for the most part, from its mounting. In contrast to the unobstructed gun muzzle in other instances, the muzzle in this case does not extend beyond the back of the gun shield and only a small hole is provided for the passage of bullets. Thus, the gases which escape at the muzzle are trapped behind the shield and are drawn into the turret by the inward flowing air. Since the inward leakage occurs around the 75 mm gun as well as the machine gun mounts, it is not practical to capture and remove the fumes by exhaust ventilation. The best solution of the problem appears to be to extend the muzzle through the shield, or, at least, to provide an opening through the shield to allow the gases to escape to the outside. Correction of this situation is essential because of the serious magnitude of the hazard which now exists.

c. Bow machine gun.

The average carbon monoxide concentration at the breathing zone of the bow gunner was 0.053% (Fig. 4) and during the test period the concentration of carbon monoxide in the bow gunner's blood did not increase seriously. The gunner reported no discomfort or eye irritation during operation of the weapon. It is concluded that ventilation is adequate for operation of the bow machine gun.

TABLE 1

CONCENTRATIONS OF CARBON MONOXIDE AND AMMONIA
From 75 MM Gun

	Peak Concentrations at End of Burst	
	Carbon Monoxide Percent	Ammonia p.p.m
After 1st Burst	0.477	255
After 3rd Burst	0.331	130
After 4th Burst	0.565	320
	Aver. Concentration by Cont. Sampling	
Loader	0.086	-
Asst. Driver	0.015	-
Clearance Rate after last burst (Time for conc. to decrease 50%)	20 seconds	

TABLE 2

CONCENTRATIONS OF CARBON MONOXIDE AND AMMONIA
From Turret Machine Gun

(Samples taken at Loader's Position)

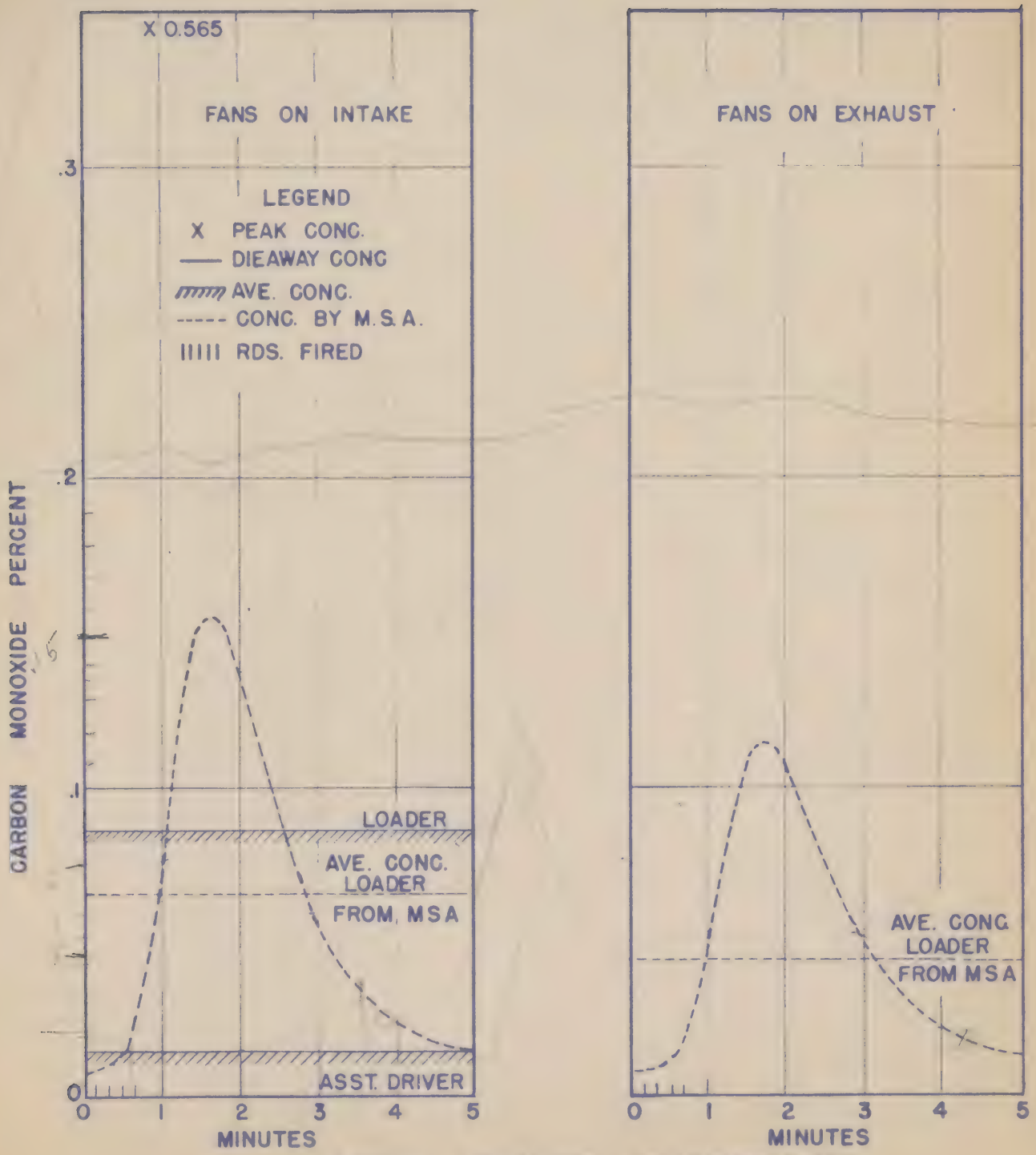
	Peak Concentrations at End of Belt	
	Carbon Monoxide Percent	Ammonia p.p.m
After 2nd Belt	0.330	115
After 3rd Belt	0.252	110
	Aver. Concentration by MSA	
Loader	0.173	

TABLE 3

BLOOD CONCENTRATIONS OF CARBON MONOXIDE IN CREW MEMBERS
After Firing Three Belts in Turret and Bow Machine Guns

(Approx. 12 Min. Exposure)

Crew Member	Carbon Monoxide Hemoglobin % of Total Pigment
Turret Machine Gun	
Gunner	23.3
Commander	16.3
Loader	13.1
Bow Machine Gun	
Asst. Driver (Gunner)	7.3



CARBON MONOXIDE CONCENTRATION
M7 TANK 75MM GUN

FIG.1

FIG.2

FIG. 3

CARBON MONOXIDE CONCENTRATION M7 TANK

CAL. 30 MACHINE GUN BY M.S.A. INDICATOR

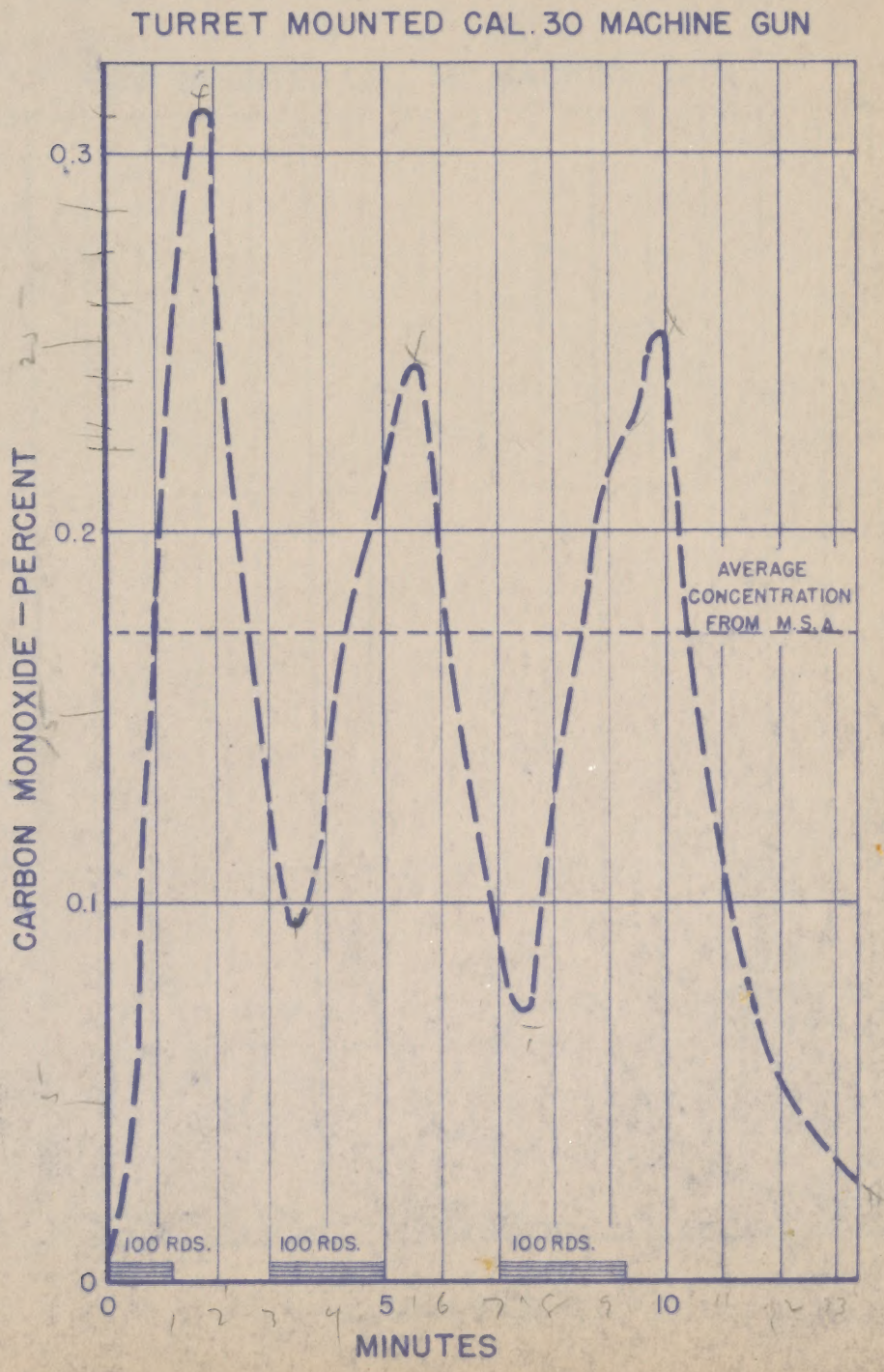


FIG. 3

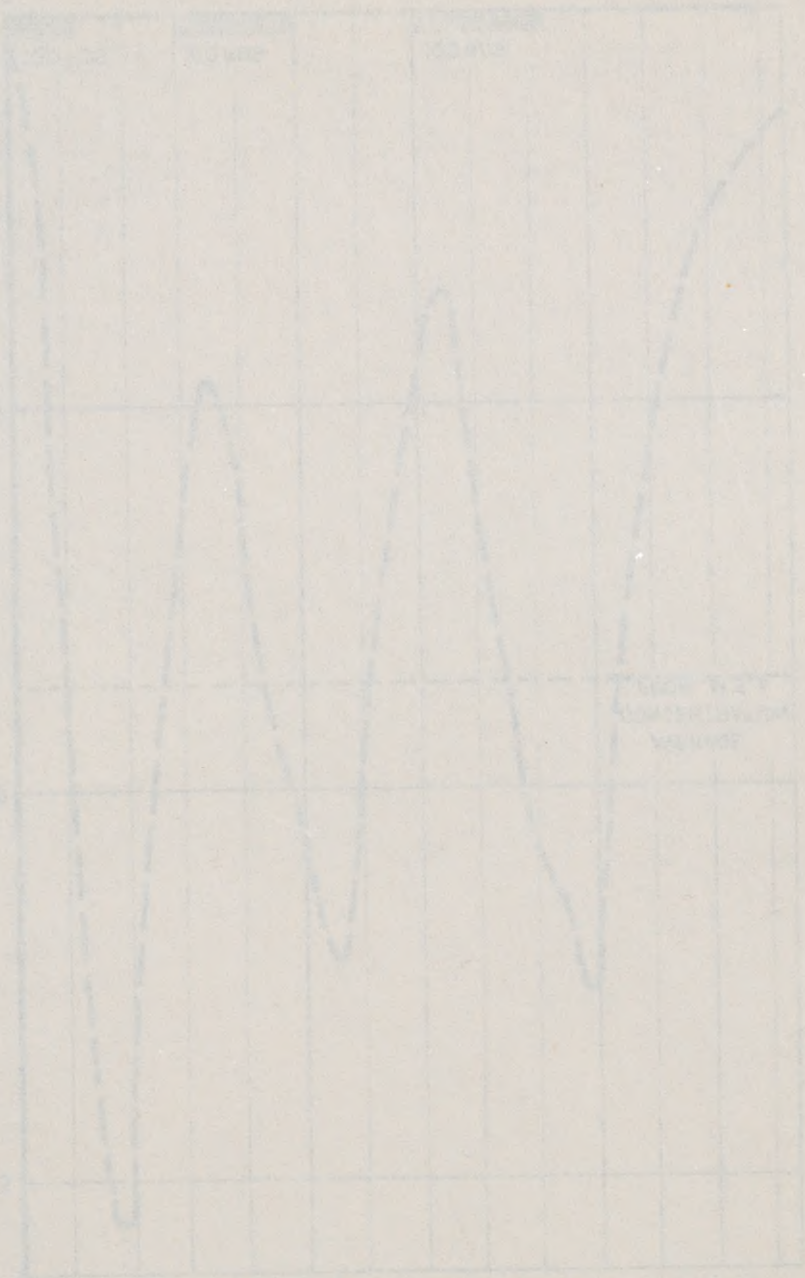


FIG. 4

CARBON MONOXIDE CONCENTRATION M7 TANK

CAL. 30 MACHINE GUN BY M.S.A. INDICATOR

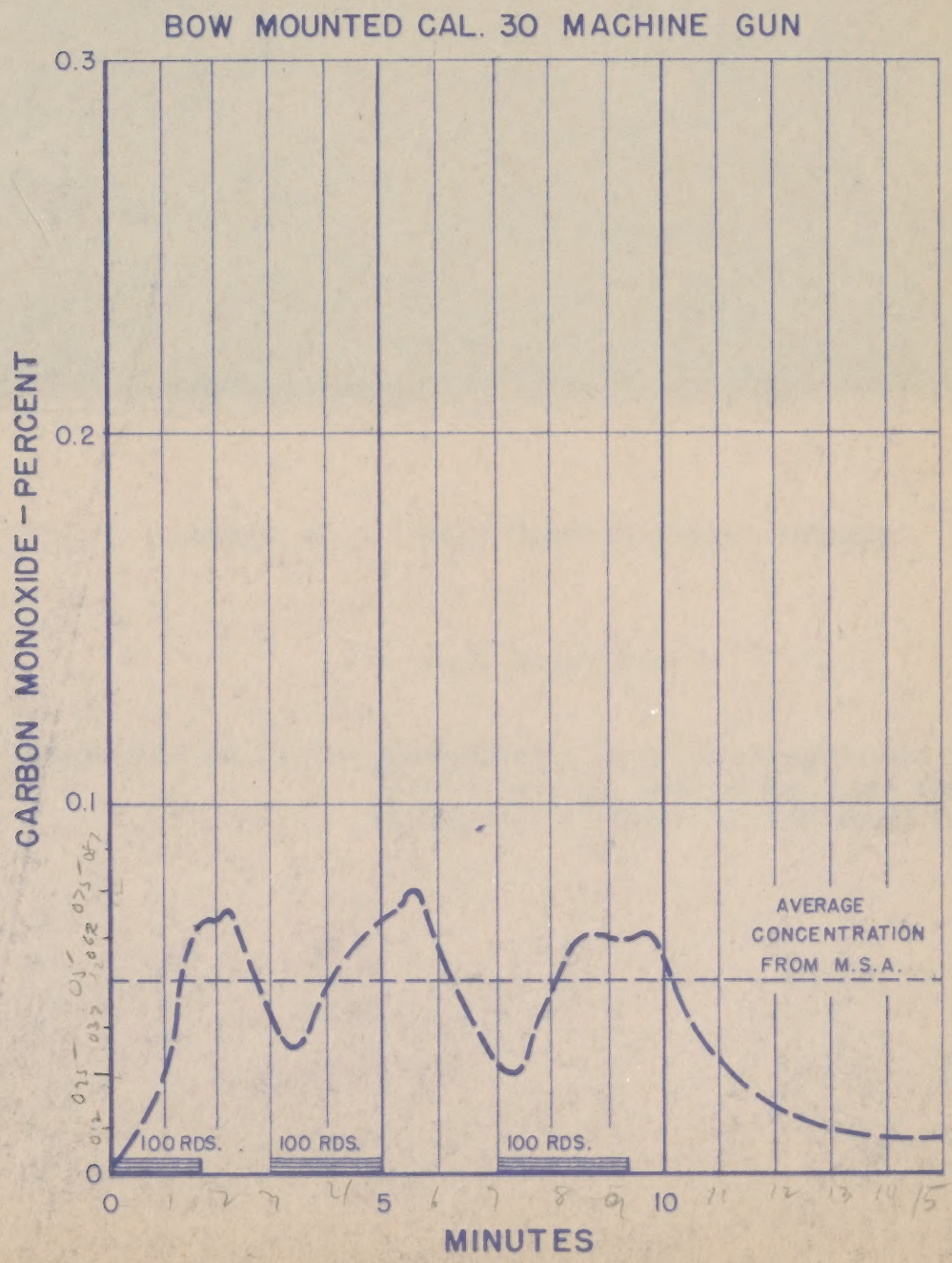


FIG. 4